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ABSTRACT

As part of an ongoing study of sex differences in spatial ability, three preliminary hypotheses on parental socialization, sex role socialization, and biological explanations were tested, using 139 high school seniors as subjects. The early findings indicated that there was no support for the hypothesis that boys and girls differ in how they view their involvement with their parents, though some parent behaviors, particularly those involving support and warmth in the parent-child relationship, were related to higher spatial performance. In addition, there was no support for the hypothesis that adolescents who reported preferring sex-typed activities and interests also were sex-typed in their performance of spatial tasks. Both boys and girls reported preferring sex-appropriate sex-typed activities and interests, but this overwhelming sex difference was unrelated to spatial ability. The final hypothesis tested--that timing of maturation exerted influence on spatial ability--was confirmed. Analyses indicated that higher spatial ability was related to later maturation. An incidental result of this preliminary research was the observation that volunteer samples for such research in spatial ability may be biased, since low ability males tended to drop out more frequently from such studies than did low ability females. (RL)

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Sex Differences in Performance on Spatial Tasks: Biopsychosocial Influences

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Acknowledgements

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One of the three cognitive tasks that show fairly consistent differences between males and females is spatial performance (Maccoby & Jacklin, 1974; Petersen & Wittig, 1979). Spatial visualizing ability is usually measured with tasks requiring a mental manipulation such as a rotation or assembly of objects or figures. Because many tasks can be solved more than one way, some assurance that a spatial visual strategy is used is achieved through a time-limited test.

Some examples of spatial visualizing tasks are shown in figure 1. Item a is a sample item from the Primary Mental Abilities test, Space subtest (Thurstone & Thurstone, 1941). This tasks requires rotations, a two dimensional spatial visualization task. The correct responses are b and e. Item b is from the Differential Aptitude Test Space. Relations subtest (Bennett, Seashore & Wesman, 1973). This, like the remaining spatial visualization items, requires a transformation in three-dimensional space. The correct response is b. Item c is from

Mental Rotations (Vandenberg, & Kuse, 1978). The correct responses are the first and third figures. Item d is from the Guilford-Zimmerman Clock test (Guilford & Zimmerman, 1953). The correct response is 2. All of these tasks are time-limited and the latter two are particularly difficult to perform using other than a spatial strategy.

Two other constructs, field independence and horizontality, show high correlations with spatial measures. Examples of these are shown in figure 2. Item a is from the Group Embedded Figures Test (Witkin, Ottman, Raskin, & Kasp, 1971); it shows a simple figure and a complex figure in which the simple figure is embedded. Item b is from the Water Level Task developed by Harris (1978). The correct response is the first container. While both of these tests intend to measure constructs other than spatial ability, both are highly correlated with spatial measures and show similar sex differences.

At around early adolescence, roughly the junior high school years, studies begin finding sex differences in favor of boys on these tasks. It is important to note that differences between males and females only appear in about sixty percent of the studies reviewed by Maccoby and Jacklin (1974). Given that publication criteria typically require that results show some differences, the actual incidence of differences between male and females samples may be lower. When differences appear however, they have almost always been in the direction of males scoring higher than females.

It is this consistency in the direction of differences, when they appear, that leads us to conclude that boys generally outperform girls on spatial tasks. A further point to note is that there is, nonetheless, a great deal of overlap in the performance of males and females. There are many girls and women who excell at spatial tasks; similarly, there are many boys and men who are poor spatial visualizers. The variability among females and among males is always larger than the variability between males and females. Indeed, on many tests of spatial performance the differences may amount only to a test item or two. (See Petersen and Wittig (1979), for further discussion of these issues.)

Many biological hypotheses have been proposed and studied to explain these sex differences. Indeed, it is interesting to note that most of the research seeking to explain sex differences in cognition has focused on biological explanations (Petersen, 1980). Perhaps the research has focused on biological explanations because these are most plausible. Alternatively, conceptual biases as well as accumulating tradition may be responsible for the nature of the work that has been done. In any case, the currently popular biological explanation is differential brain lateralization. There are, however, several other possibilities to consider.

Any explanation for the sex differences must also explain the timing of their emergence at early adolescence. Anyone studying, or indeed, working with young adolescents quickly becomes aware of the many things that are in flux for these youth. Puberty is probably the most salient change but there are other changes as well (see Petersen & Taylor, 1979). School composition, the daily schedule changes, and the school curriculum make

different demands on young people. The school student composition (i.e., homogeneous age groupings), among other factors, also contributes to the emergence of strong peer groups and pressures toward conformity at this age. Sex role orientation and gender identity become more salient because the changes in physical appearance emphasize the maleness or femaleness of young adolescents. Relationships with parents and other significant adults also undergo changes during these years. Cognitive capacities change qualitatively as well as quantitatively during early adolescence in many young people. Thus, there are numerous influences on the lives of the young adolescent, some related to the biological changes of puberty and others more closely linked to social structural changes in the environment. Several of these influences, alone or in combination, could be hypothesized as causes of the emergence of sex differences in spatial ability at this time.

Because the sex differences in the performance of spatial tasks appear to be influenced by multiple causes, it is necessary to consider their development from within a framework for biopsychosocial development (Petersen, 1980). Figure 3 roughly portrays a schema for biopsychosocial development over the life span. At some ages we know that biological influences are key; at other ages, social influences may be more important. The main point, however, is that throughout the life cycle we are influenced by biological, psychological, and social factors. These factors interact continually throughout life with reciprocal effects.

Given this general framework, we have considered the development of

sex differences in spatial ability from a biopsychosocial perspective. Figure 4 shows factors in these various spheres that have been found to have some influence on sex differences in spatial ability (Petersen, 1979). On the biological side, genes, hormones (prenatal, pubertal and cyclic), timing of maturation, and brain lateralization have all both proposed as factors. On the social side, there are sex role stereotypes about what kinds of tasks, activities, and courses each sex is supposed to be good at. Psychological factors include the individual's extent and kind of sex role identification as well as attitudes and values. A component of influence not in this model is socialization from parents. Previous research had not examined this factor in relation to spatial ability but it is one that researchers have found to relate to sex-typed behaviors of other kinds.

We are currently completing a study to test the various factors hypothesized to be important for producing sex-related differences in spatial ability. We are interested in the development of sex differences in cognition as well as the factors influencing performance. In this study we assessed factors from each of the possible spheres of influences. Figure 5 lists the constructs in each area: Biological, Psychological, and Social as well as Cognitive. Furthermore, we assessed strategies used in the spatial tasks to learn what factors besides mental processing contributed to the score obtained.

Given that sex differences are often found with spatial ability, we wanted to try to unconfound these two factors. For example, if most

of our high spatial visualizers were boys, we want to be clear whether other attributes are due to their sex or to their cognitive capacities. To do this, our sampling design involved two strata: sex and spatial ability. We sampled randomly within these strata. The next figure show our sampling design. This sampling strategy overselects the extreme groups, so that in our sample we are likely to have more high spatial ability girls and more lower spatial ability boys than would be obtained with a random sample. One interesting result of our design is that when we looked at who our dropouts had been, the group of low spatial ability boys was grossly over represented. Girls with the same low ability just didn't dropout. These results suggest that volunteer samples in general may lose these boys, thus biasing the results.

The subjects for our study were high school seniors in two large middle-class suburban high schools. We didn't want to have subjects any younger, as then the biological measures, as well as other measures, are more confounded with timing of maturation. While we are interested in the timing of pubertal maturation, we did not want to be sampling during that process. We chose high school students as subjects because of our particular interest in these processes during adolescence; in addition, high school samples are generally more likely than college samples to be representative of the broader population.

I would like to summarize for you some of our analyses testing the model described earlier. We're just beginning this phase of the research so I don't have final conclusions to report. What follows are some of our early findings.

We so far have tested three general hypotheses that might explain sex differences in spatial ability. These preliminary hypotheses include parental socialization, sex role socialization, and biological explanations.

Parental socialization. We tested the hypothesis that parents socialize boys and girls differently, and that such differential socialization, if it exists, is related to different spatial performance (Gitelson, 1980.) An example of sexually differential socialization would be teaching boys to be aggressive or assertive and girls to be passive or submissive. We found that adolescents report that their mothers differ from their fathers in how they are treated. We found no support, however, for the hypothesis that boys and girls differ in how they view their involvement with their parents. We did find that some parent behaviors, particularly those involving support and warmth in the parent-child relationship, are related to higher spatial performance. Both boys and girls who perform well on spatial tasks report such involvement with parents, therefore the results for boys and girls were combined. Figure 6 is representative of these results, showing the warmth scale. Perhaps if our sample had not unconfounded sex from spatial ability, we would have found evidence for differential treatment. The present results suggest that that would have been an erroneous inference. We are looking further at parental socialization, with particular focus on factors such as identification with parents, parental encouragement or discouragement of sex-typed courses, among others.

Sex role socialization. It has been hypothesized that people are motivated, through learning or instinct, to behave in ways that are considered appropriate for their sex. Conformity to peer pressure peaks during adolescence (Costanzo & Shaw, 1966) and sex role stereotypes are most rigidly endorsed during these years (Benson & Vincent, 1980). People vary in the extent of their conformity to or endorsement of sex-stereotyped behaviors or characteristics (Bem, 1974). Thus, the extent of conformity to sex-stereotyped behaviors or characteristics might influence the extent to which an individual is motivated to perform well on a cognitive task considered to be more appropriate for one sex than the other. Some previous research has supported this hypothesis (e.g., Connor & Serbin, 1977). In this study, we examined whether adolescents who report preferring sex-typed activities and interests also are sex-typed in their performance of spatial tasks (Tobin-Richards, 1980). We found no support for this hypothesis. Both boys and girls reported preferring sex-appropriate sex-typed activities and interests and this overwhelming sex difference was unrelated to spatial ability. Similar results were obtained with measures of sex role orientation; the sex differences were huge but no associations with spatial ability group were found. We speculate from these latter results that we need to look at the activities of adolescents in a different way. Given the strong pressures to conform during adolescence, and in particular, the strong pressure to conform to sex role stereotypes, there may be little room, for individual variability. Where variability may exist is within sex-appropriate activities or interests.

For example, we had in our sample several high spatial ability girls who were very interested in the visual arts. This is an acceptable activity for a girl that may relate to spatial proficiency.

Biological factors. The final hypothesis tested thus far is that timing of maturation, through the mechanism of brain lateralization, exerts influence on spatial ability. Waber's (1976, 1977) hypothesis was that sex differences in spatial ability appeared because the brain becomes more lateralized with later pubertal development. More extensive lateralization is thought by some to facilitate greater spatial proficiency. Thus, boys are better spatial visualizers than girls because their pubertal development occurs about two years later. This is an appealing hypothesis because it explains both the sex difference and the timing of its occurrence. Previous research of ours (Petersen, 1976; Herbst & Petersen, 1979), however, has failed to replicate Waber's result. In the present study, though, we did obtain an association between spatial ability groups and timing of maturation such that higher ability was related to later maturation (Herbst & Petersen, 1980). Figure 7 shows the results. We speculate that this effect is a weak one and is only apparent when extreme groups are sampled, as was the case in this study as well as Waber's. We found no association, however, with a dichotic listening measure of brain lateralization. So we are left with the basic result of a timing effect without evidence for the hypothesized mechanism. We are continuing to study this.

We recently began looking at how timing at maturation and sex role

orientation together might explain spatial proficiency. Timing is the best predictor for both boys and girls though it explains relatively little of the variability in spatial ability (7% and 10%, respectively, for boys and girls). What is interesting, however, is that high masculinity is next most important for girls while low femininity is next most important for boys. (These are separately and independently measured.) So later maturation and higher masculinity tend to predict higher spatial ability for girls while later maturation and lower femininity tend to predict higher spatial ability for boys. We hope that further analyses will begin to clarify what factors are important as well as how they combine to produce spatial ability.

Besides seeking to understand how spatial ability might develop, we also want to learn more about what the scores from tests of spatial ability mean. We individually administered every task or test in our study. After four of the tests of spatial ability, we asked a series of questions about the certainty of accuracy with selected items as well as about the strategy used to solve each. In five of the six cases where certainty was relevant, boys were significantly more certain than girls that they had answered correctly. In only one of six cases, were boys in fact correct more often than girls. So girls appear to have less confidence in their performance, even though their performance is generally similar. With two of the four spatial tasks, boys were more likely than girls to have used what we considered to be a more effective strategy. Spatial ability group was a significant factor with all of these variables: correctness, certainty, and effectiveness of strategy. We will be looking more at the strategies to see what we can learn about spatial performance.

We have many hypotheses yet to pursue. For example, previous research of mine had indicated that adolescent boys and girls who were neither extremely masculine nor feminine, respectively, in appearance were the most likely to be better spatial visualizers (Petersen, 1976). I hypothesized that this was due to some effect of hormones, either prenatal or pubertal. A recent study has failed to replicate this result (Berenbaum & Resnick 1980) but we plan to take a further look at this in our data.

Whatever we end up with as "the" model for sex differences in spatial ability, we feel strongly that it is important to explore all reasonable hypotheses. Looking to only one body of explanations, in this case biological ones, is a little like searching only under the streetlight because it's brighter there. The answer may lie somewhere still in the dark. Virtually unexplored are possibilities for different experiences affecting brain development and lateralization. For example, Tobias (1978) speculated that greater spatial proficiency of boys might be related to their more extensive experience with throwing and catching objects moving through space, as well as moving themselves in complex relationships with other players. A graduate student in our laboratory (Richards, 1980) took a look at this and found such an association for boys, though not for girls.[1] This result is shown in figure 8. We intend to pursue such hypotheses further.

In our search to understand sex differences in spatial ability our basic assumption is that we are biological bodies, with psychological characteristics, functioning within complex social systems. Over the

course of development these aspects influence one another. Our environment, both social and physical can affect our biological and psychological health. Similarly, biological state can affect psychological state and social relationships, and vice versa. Sex differences are especially important to consider within this complex framework since sex is not simply a biological variable. Beginning relatively early in life, we begin to have projected upon us and identify with all of those things that a boy or a girl "ought" to do or be like. To consider sex differences in this complex fashion is messy, both conceptually and methodologically. But human behavior -- and sex differences in it -- is complex. Therefore, our study designs and conceptualizations must be also.

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Figure Legends

Figure 1. Examples of items measuring spatial visualization ability: a. Primary Mental Abilities Space subtest, b. Differential Aptitude Test Space Relations subtest, c. Mental Rotations d. Guilford-Zimmerman Clocks Test.

Figure 2. Examples of items highly correlated with tasks requiring spatial visualization: a. Group Embedded Figures Test, b. Water Level task.

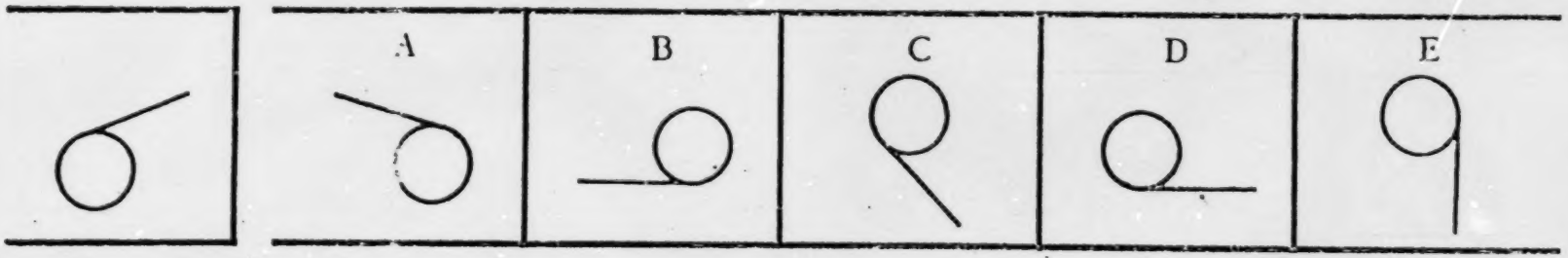
Figure 3. A hypothetical model for biopsychosocial development over the life span. (From Petersen, 1980; reproduced with permission.)

Figure 4. A model for biopsychosocial influences on sex differences in cognition. (From Petersen, 1979; reproduced with permission.)

Figure 5. Parental socialization (warmth) and spatial performance.

Figure 6. Timing of maturation and spatial performance.

Figure 7. Athletic skill and spatial performance.



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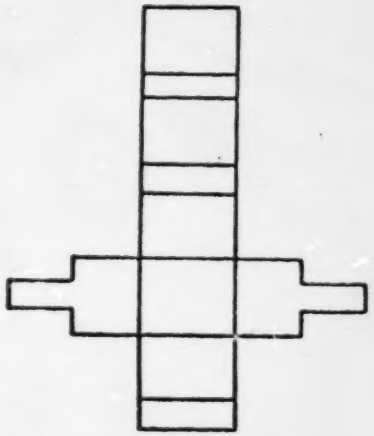

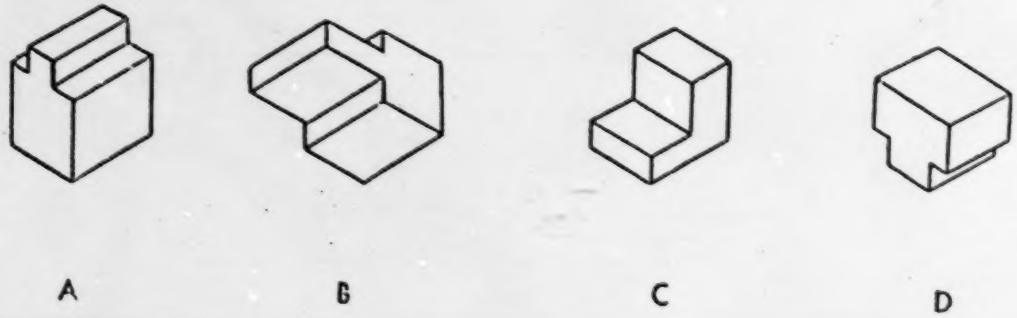

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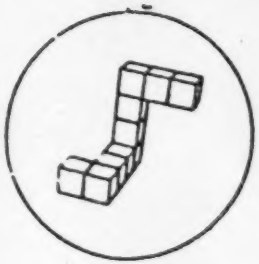

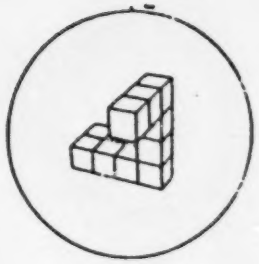

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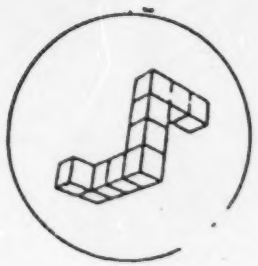

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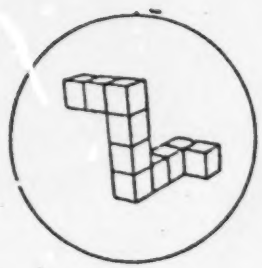

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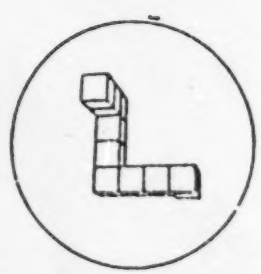

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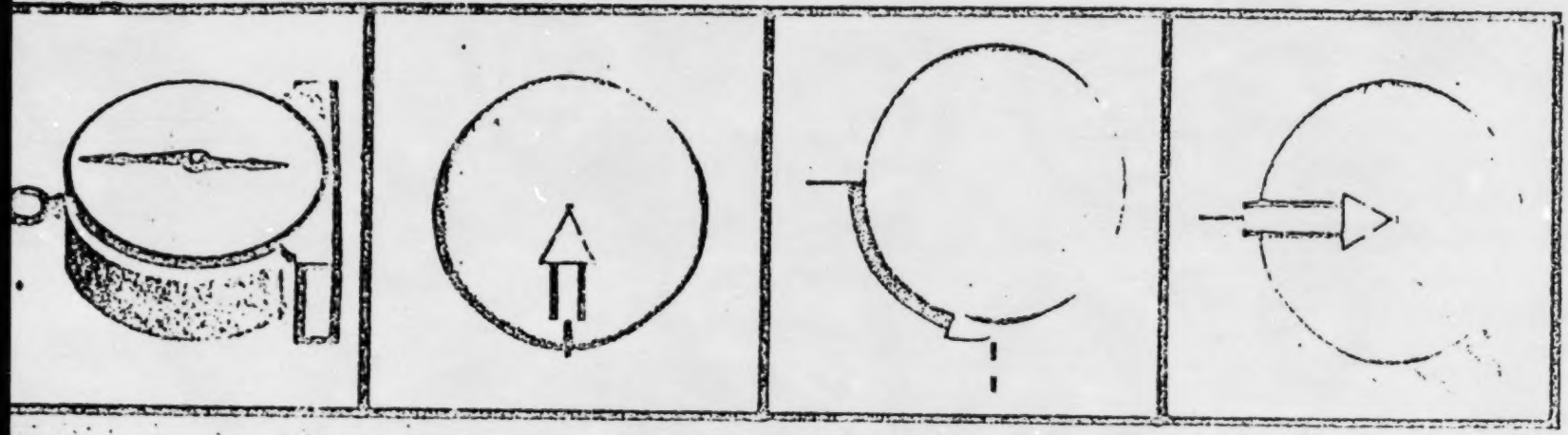

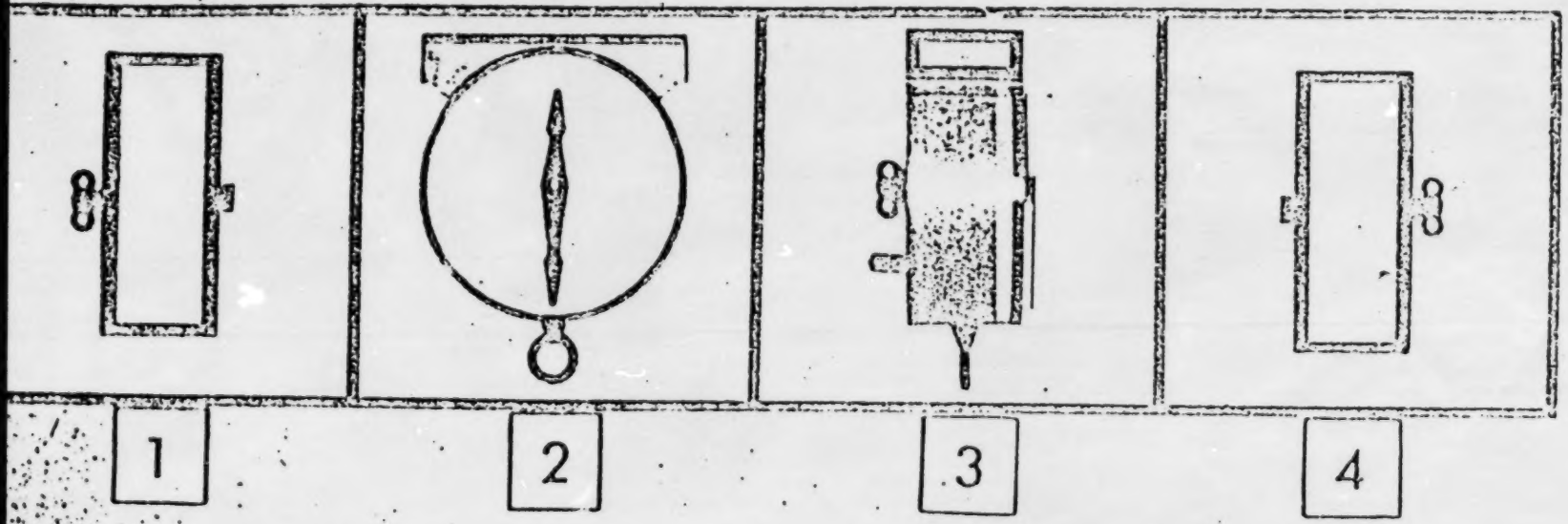
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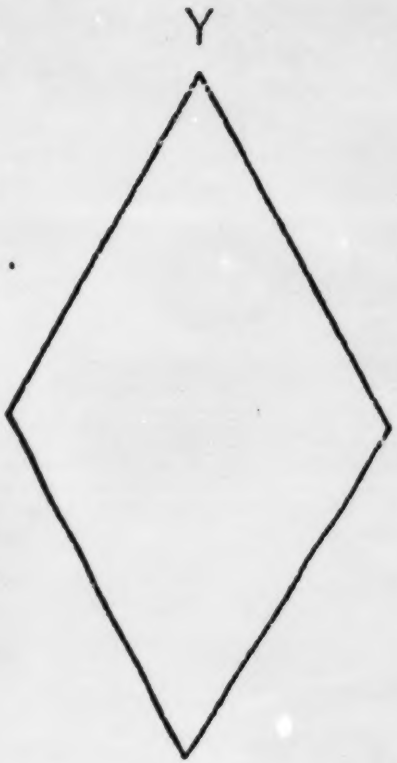

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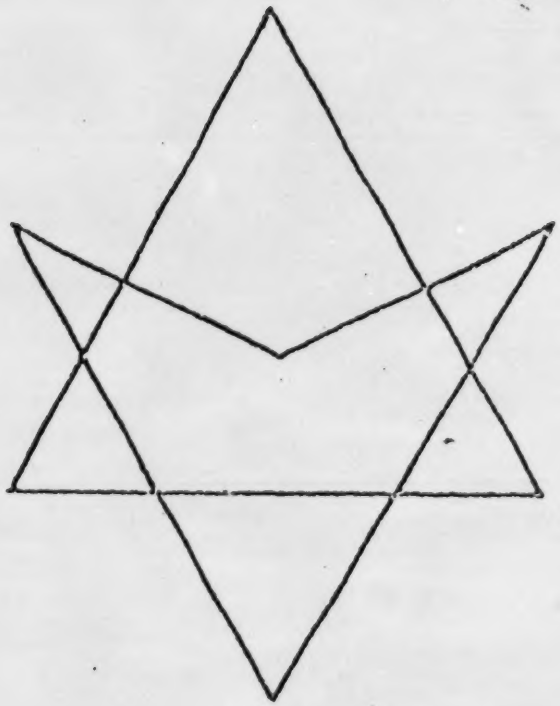

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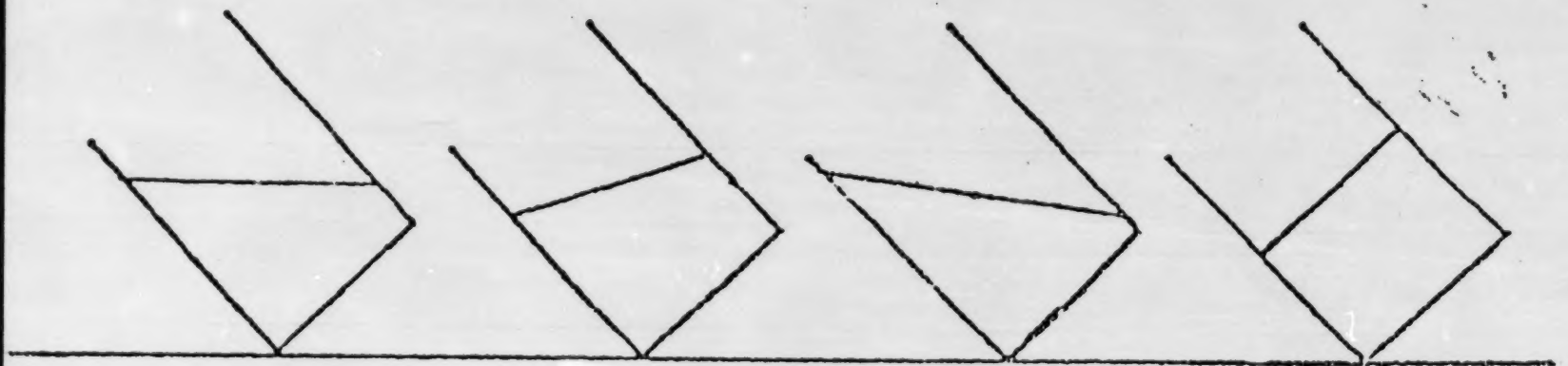

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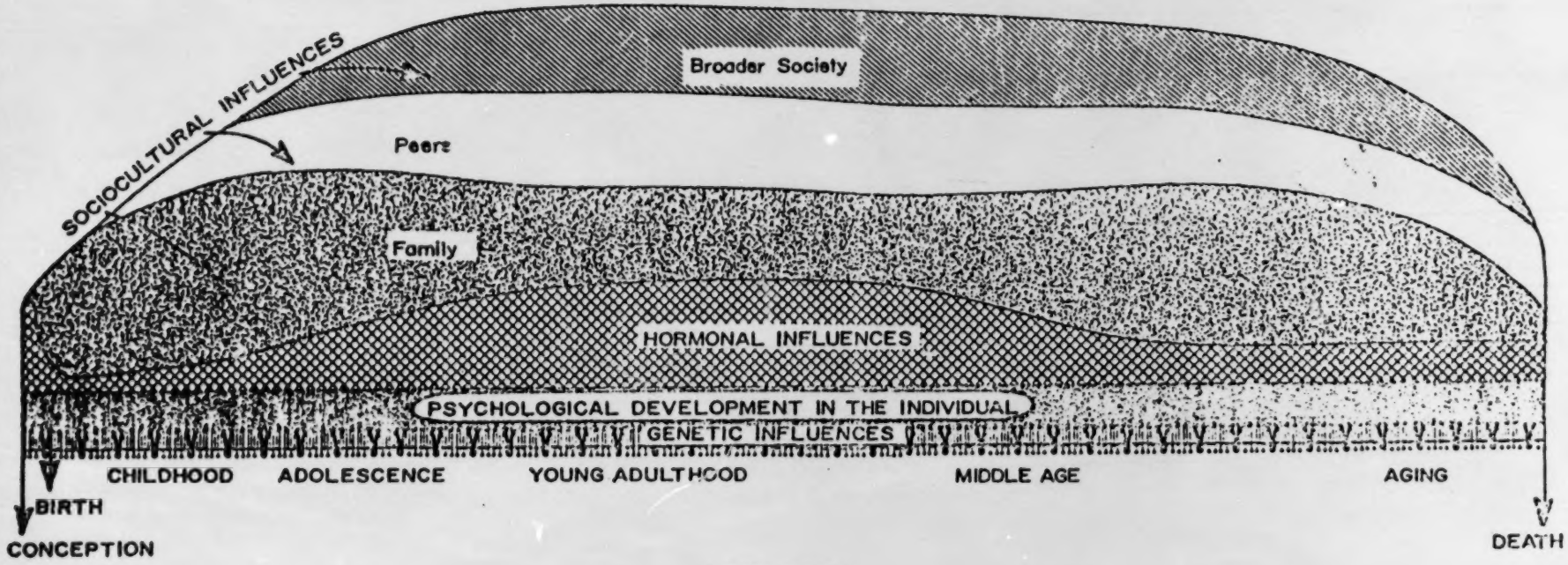
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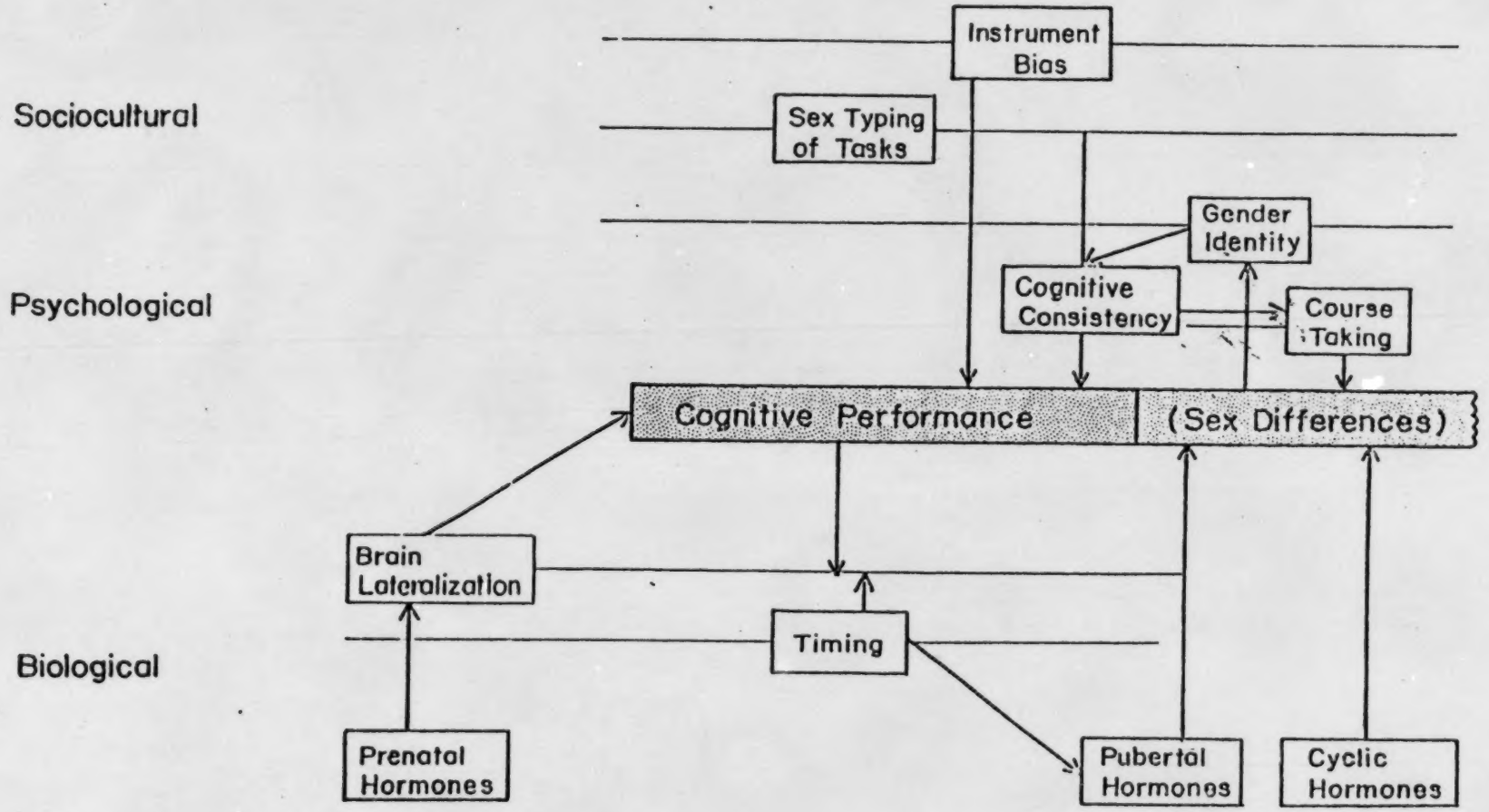
LEVELS OF INFLUENCES



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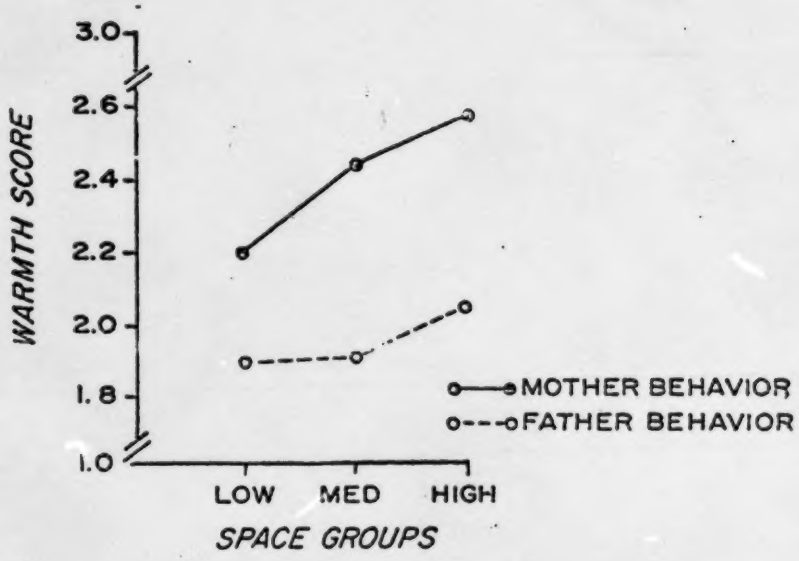
PHASES OF DEVELOPMENT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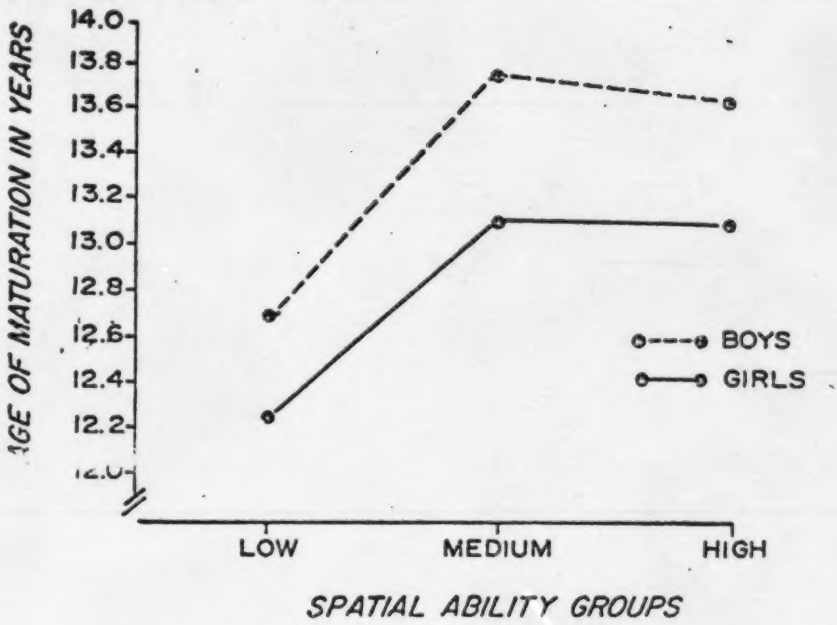
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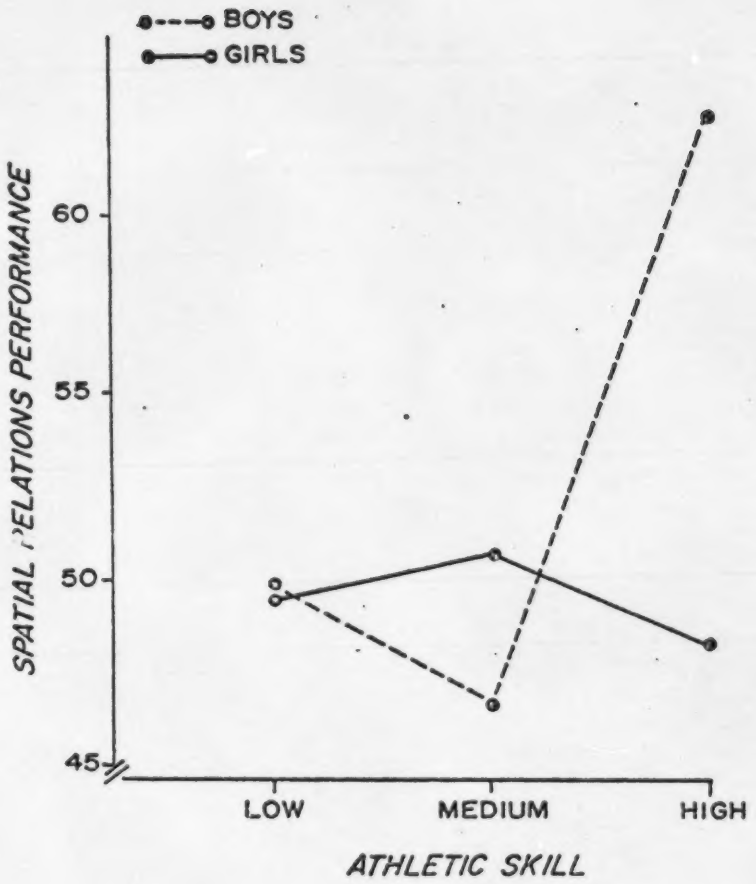
AGE OF MATURATION IN YEARS
BOYS
GIRLS
LOW
MEDIUM
HIGH
SPATIAL ABILITY GROUPS


BOYS
GIRLS
SPATIAL RELATIONS PERFORMANCE
60
55
50
45
LOW
MEDIUM
HIGH
ATHLETIC SKILL

Spatial Tasks

Table 1

Biological, Psychological, and Sociocultural

BIOLOGICAL FACTORS

Brain Lateralization	Dichotic Listening Task (Syllables)
Handedness	Edinburgh Handedness Inventory
Maturation Rate	Age at menarche Age at most rapid growth
Physical Androgyny	Self ratings Interviewer ratings

PSYCHOLOGICAL FACTORS

Sex Role	Bem Sex Role Inventory (adapted)
Attitudes	Attitudes Toward Women Scale for Adolescents
Self Esteem	Rosenberg Self Esteem Inventory
Ego Development	Loevinger Sentence Completion Test

plus various questions and measures from the individual interview

SOCIOCULTURAL FACTORS

Family	Configuration (Birth order, sibling sex, etc Parent Behavior Form Encouragement of courses, activities
Education	Courses taken, interests, reasons
Activities	Music Athletics Strategy games Hobbies Fraser Activity Scale

Table II

COGNITIVE MEASURES

Spatial Ability	Vandenberg Mental Rotations DAT Space Relations Embedded Figures Test Water Level Task
Verbal Ability/ Fluent Production	DAT Clerical Speed & Accuracy DAT Spelling Stroop Color Naming Quick Test
Cognitive Development (Formal Operations)	Linn Balance Test Linn License Plates
Social Cognition	Selman Interpersonal Awareness Interview

Table III

SAMPLING DESIGN AND FINAL SAMPLE

DESIGN

	Spatial Ability Groups[1]			
	Low	Middle	High	Totals
Boys	25	25	25	75
Girls	25	25	25	75
Totals	50	50	50	150

SAMPLE

	Low	Middle	High	Totals
Boys	16	24	27	67
Girls	23	25	24	72
Totals	39	49	51	139

[1] measured by the Guilford-Zimmerman Clocks Test.